

Original Article

Morphological, sensory and biochemical characteristics of summer apple genotypes

Características morfológicas, sensoriais e bioquímicas de genótipos de maçã cultivada no verão

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Abstract

Summer apples are one of the most important plant community in Artvin province located Northeastern part of Turkey. In present study 22 local apple genotypes were characterized by phenological, morphological, biochemical and sensory properties. Harvest date was the main phenological data. Morphological measurements included fruit weight, fruit shape, fruit ground color, fruit over color, fruit over color coverage and fruit firmness, respectively. Sensory measurements were as juiciness and aroma and biochemical characteristics included organic acids, SSC (Soluble Solid Content), vitamin C, total phenolic content and antioxidant capacity. Genotypes exhibited variable harvest dates ranging from 11 July to 13 August and cv. Summered harvested 30 July 2017. The majority of genotypes were harvested before cv. Summered. Fruit weight were also quite variable among genotypes which found to be between 89 g and 132 g, and most of the genotypes had bigger fruits than cv. Summered. Pink, red, yellow and green fruit skin color was evident and main fruit shape were determined as round, conic and oblate among genotypes. ART08-9, ART08-4, ART08-21 and ART08-22 had distinct bigger fruits and ART08-1, ART08-2, ART08-5, ART08-12 and ART08-17 had higher total phenolic content and antioxidant capacity. The results of the study showed significant differences for most of the phenological, morphological, sensory and biochemical characteristics. Thus, the phenological, morphological, sensory and biochemical characteristics of summer apple genotypes were distinguishable and these results suggest that phenological, morphological, sensory and biochemical differences of the summer apple genotypes can be attributed to differences in genetic background of genotypes which placed different groups by PCoA analysis.

Keywords: early ripening apples, diversity, genetic resources.

Resumo

As maçãs cultivadas no verão são uma das culturas vegetais mais importantes da província de Artvin, localizada no nordeste da Turquia. No presente estudo, 22 genótipos locais de maçã foram caracterizados quanto às suas propriedades morfológicas, bioquímicas e sensoriais. As características analisadas foram peso do fruto, data da colheita, forma do fruto, coloração da casca, firmeza do fruto, suculência, aroma, teor de ácidos orgânicos e de sólidos solúveis, vitamina C, teor fenólico total e capacidade antioxidante. Os genótipos exibiram datas de colheita que variaram de 11 de julho a 13 de agosto, e a cultivar de verão foi colhida em 30 de julho 2017. A maioria dos genótipos foi colhida antes da cultivar de verão. O peso dos frutos também foi bastante variável entre os genótipos, apresentando entre 89 e 132 g, e a maioria dos genótipos apresentou frutos maiores que a cultivar de verão. As colorações rosa, vermelho, amarelo e verde da casca dos frutos foram as mais evidentes, e a forma principal dos frutos foi determinada como redonda, cônica e oblata entre os genótipos. ART08-9, ART08-4, ART08-21 e ART08-22 apresentaram frutos maiores distintos, e ART08-1, ART08-2, ART08-5, ART08-12 e ART08-17 apresentaram maior conteúdo fenólico total e capacidade antioxidante. Os resultados do estudo mostraram diferenças significativas para a maioria das características morfológicas, sensoriais e bioquímicas. Assim, essas características dos genótipos da maçã cultivadas no verão foram distintos, e esses resultados podem ser atribuídos a diferenças no contexto genético dos genótipos.

Palavras-chave: maçãs de maturação precoce, diversidade, recursos genéticos.

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1. Introduction

The development of agriculture has been based on natural biodiversity, and crops were selected by identifying, manipulating and managing the domestication of wild species. Thus, modern crops are the result of a complex evolutionary process, which involves the creation of diversity and selection (Ercisli et al., 2008; Serce et al., 2010; Senica et al., 2019). The benefits of increased production, incomes, and human wellbeing derived from agricultural development are associated with negative consequences of the increasing genetic uniformity of food crops (Ersoy et al., 2018a, b; Eyduran et al., 2015a, b; Gecer et al., 2020).

The apple (*Malus × domestica* Borkh., family Rosaceae, tribe Pyreae, $2n = 2x = 34$) is one of the most ancient and widespread fruit crops in temperate regions of the world. The People's Republic of China produces the largest amount of apples, and followed by the United States, Poland, and Turkey, in order (FAO, 2018). Apple trees can be found almost every continent in the world and gave better fruiting behavior in temperate regions in the world (Butiuc-Keul et al., 2019).

Apple has different visual and non-visual characteristics including fruit color, appearance, size and uniformity with beautiful crispy flesh, pleasant flavor, texture, and taste that attract the consumers (Asif Ali et al., 2004). The fruit is also has nutritional value and bioactive content (Skendrovic Babojelic et al., 2007; Mikulic Petkovsek et al., 2009). Apple is mostly consumed as fresh due to storable capacity and matured from late summer to winter and classified as summer, autumn and winter apples. Cultivar/genotype, ripening stage, tree age, training system, soil and weather conditions strongly affects external and internal characteristics of apple fruit (Markuszewski and Kopytowski, 2008; Milosevic et al., 2019).

Apple has high genetic variability and the thousands of summer, autumn and winter apple cultivars distributed throughout the world. However, the number of the summer apple genetic resources used by breeders has been limited and reduced to a few cultivars such as Jersey Mac, Vista Bella and Summered. Summer apple cultivars generally ripen in July-August and are offered directly to the market without storage (Noiton et al., 1998).

This massive use of limited summer apple cultivars, combined with vegetative practices based on grafting, has dramatically reduced summer apple genetic diversity and, hence, many interesting and well adapted traditional and local summer apple cultivars/genotypes considered obsolete, were no longer cultivated and have been partly lost (Hammer et al., 2003).

In Turkey, western regions has intensive modern apple orchards by using introduced cultivars. However, in north and eastern regions of Turkey, apart from few family-run orchards, fruit production was, and currently remains, mainly directed toward self-consumption and local markets. In these regions many of these cultivars/genotypes, although of low productivity, were relatively stable under extreme environmental conditions, and their high genetic variability guaranteed reliable harvesting for local communities in the past. However there were no in situ and ex situ conservation of summer apples in Turkey (Ercisli, 2004).

The present research aims to understand the phenological, morphological, sensory and biochemical variability of local summer apple genotypes in northeastern Turkey for a better management of conservation and propagation of summer apple genetic resources.

2. Material and Method

2.1. Plant material and sampling

In this study, twenty two summer apple genotypes (Named from ART08-1 to ART08-22) sampled Artvin region in northeastern of Turkey were used. The genotypes found randomly in different orchards as solitary trees and all genotypes first time was studied in present research. The standard summer apple cultivar Summered was also included to study to make comparison with local genotypes. The fruits from each genotype were harvested in the periods when the fruits in commercial maturity stage in 2017. The fruit samples picked homogenously and morphological (harvest date, fruit weight, fruit firmness, shape, color) and sensory (taste, juiciness and aroma) and biochemical (organic acids, SSC, vitamin C, total phenolic content and antioxidant capacity) characteristics were done on 30 fruits after harvest.

2.2. Phenological observations

Harvest date of genotypes were classified according to D.U.S guideline as: Very early ripening (18 May-27 June), Early ripening (28 June-17 July), Early-mid-ripening (18 July-27 July) and Mid ripening (28 July-6 August).

2.3. Sensory evaluation

A trained panel of five experts evaluated the sensory features (taste, juiciness and aroma) of fruits for each genotype. The 0 to 9 bipolar hedonic scale just described was used to rate overall liking of taste, juiciness and aroma which was rated on a unipolar 0 to 9 intensity scale, where 0 = not detectable, 1 = just barely detectable, 3 = slight, 5 = moderate, 7 = intense and 9 = extremely intense. The term 'aromatics' was used to denote all flavour components not covered by sweetness and sourness; no specific aromas were expected to be identified.

2.4. Morphological analysis

Fruit weight (g) was measured with a digital scale sensitive to 0.01 g (Scaltec SPB31). Fruit firmness was determined with non-destructive Acoustic Firmness Sensor (Aweta B.V., The Netherlands) expressed as kg/cm². The skin ground and over color were determined by observation and comparison. Surface area of the over color was evaluated as percentage. The shape was determined by dividing fruit length by fruit width.

2.5. Biochemical analysis

Biochemical characteristics were done on fruits that were stored at refrigerator -20 °C until their laboratory

analyses were conducted. Soluble Solid Content (SSC) were determined by extracting and mixing one drops of juice from the each fruit into a digital refractometer (Kyoto Electronics Manufacturing Co. Ltd., Japan, Model RA-250HE) at 22 °C. Vitamin C (Ascorbic acid) was quantified with the reflectometer set by using RQFlex (Merck Company, Darmstadt, Germany) and expressed as mg/100 g. In the extraction of organic acids, the method developed by Bevilacqua and Califano (1989) was modified and used. About 200 g of samples was fragmented, and 5 g from each sample was transferred to centrifuge tubes. The 10 mL of 0.009 N H₂SO₄ was added to the samples, and the samples were homogenized with Heidolph Silent Crusher M, Germany. Then, the samples were mixed for an hour with a shaker (Heidolph Unimax 1010, Germany) and centrifuged at 15,000g for 15 min. The supernatant was passed through coarse filter paper, then twice in 0.45 µm membrane filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA), and last in the SEP-PAK C18 cartridge. The concentration of organic acids was determined by HPLC using an Aminex column (HPX-87H, 300 mm × 7.8 mm, Bio-Rad) fitted on an Agilent 1100 series HPLC G 1322 A, Germany). Organic acids were detected at 214 and 280 nm wavelengths. As the mobile phase, 0.009 N H₂SO₄ was passed through 0.45 µm filter membrane.

Total phenolic were detected with Folin-Ciocalteu (FC) assay according to Singleton and Rossi (1965). Apple extracts (0.15 mL) were mixed with 0.5 mL of FC reagent. After standing for 5 min at room temperature 2.0 mL of (20% w/v) sodium carbonate solution were added and deionized water was added to a final volume of 10.0 mL. The solutions were mixed and allowed to stand for 1 h at room temperature. Then, the absorbance was measured at 760 nm, using a UV-visible spectrophotometer. A calibration curve was prepared, using a standard solution of gallic acid (20, 40, 60, 80 and 100 mg/l). Results were expressed on fresh weight basis (FW) as mg gallic acid equivalents per 100 g of fruit (peel+flesh).

Antioxidant capacity was determined using DPPH method. Fruit juice samples were obtained by pureed and filtered. Sample solution (1 mg/mL; 1 mL) was added to 4 mL of a 0.004% methanol solution of DPPH. The sample absorbance was read at 517 nm after a 30 min incubation at room temperature in the dark. Results expressed as µmol of vitamin C equivalent/g fresh weight (Nakajima et al., 2004).

2.6. Statistical analysis

All data were analyzed using SPSS software and procedures. Analysis of variance tables were constructed using the Least Significant Difference (LSD) method at $p < 0.05$. The principal coordinate analysis (PCoA) was performed to show the relationships and differentiation of the morphological and biochemical traits of summer apple genotypes in a three-dimensional array of eigenvectors using the DCENTER and EIGEN modules of NTSYS-pc 2.10e software.

3. Results and Discussion

3.1. Phenological observations

Table 1 indicate harvest dates of summer apple genotypes and cv. Summered grown in Artvin province in Turkey. Harvest dates of genotypes were found to be the one of the most distinct character. The harvest dates varied from 11 July (ART08-3 and ART08-8) to 13 August (ART08-12). The standard cultivar Summered harvested 30 July. The majority of genotypes harvested before cv. Summered indicating their importance as genetic resources (Table 1). According to D.U.S scale, harvest date of genotypes were classified as early ripening (4 genotypes), early-mid-ripening (10 genotypes) and mid ripening (8 genotypes). The standard cultivar Summered also included mid ripening group. Hajnajari et al. (2019) reported that 53 hybrids of summer apples grown in Iran were individuated according to D.U.S scale as very early, early, mid-early and mid-ripening fruits. The harvest for early-season apple cultivars (summer apples) begins in mid-summer and peaks in late summer. The harvest for mid-season apples begins in late summer and peaks in early autumn (autumn apples), and the harvest for late-season apples begins in early autumn and peaks in late autumn—and sometimes runs right into early winter (winter apples). Late-season apples are the best keepers (Kaya et al., 2015).

3.2. Morphological traits

Fruit weight one of the most important and distinct trait in apple and there were a wide range variability in apple cultivars. In present study fruit weight values of genotypes ranged from 89 g (ART08-3) to 132 g (ART08-9). The standard summer apple cultivar Summered had 104 g fruit weight (Table 1). Results indicated statistically significant differences among genotypes in terms of fruit weight ($p < 0.05$). Sixteen genotype had higher fruit weight than cv. Summered indicating importance of summer apple genetic resources. In literature a few study was reported on fruit weight in summer apple because most of the apple cultivars belongs to late season (autumn or winter) apples due to their long storable capacity. In Iran, Hajnajari et al. (2019) reported fruit weight between 11.47 g and 98.50 g in 31 promising hybrids of summer apples. In Turkey summer apples are abundant in particular middle, north, east Anatolia and previous studies on summer apples indicate great variability on fruit weight ranging from 32.29 g to 139 g (Ozrenk et al., 2011).

Twenty-two summer apple genotypes showed diversity on fruit shape and nine genotypes had oblate, eight genotypes had round and five genotypes had conic fruit shape. The cv. Summered had oblate fruit shape (Table 1). Kaya et al. (2015) reported conic, round, oblate and cylindrical fruit shapes among 37 apple selection from Van lake basin in Turkey. The fruit shape index (FSI) is the ratio between fruit length and diameter, and represents one of the most important traits of apple fruit external quality trait for fresh market and, thus is a priority breeding objective (Hazbavi, 2014). In particular in East Asia, cultivars with large FSI have greater economic potential in the fresh-

Table 1. Phenological and some pomological characteristics of summer apples.

Genotypes	Fruit weight (g)	Harvest dates	Shape	Fruit ground color	Fruit over color	Over color coverage (%)	Fruit firmness (kg/cm ²)
ART08-1	111c	17 July	Conic	Green	Red	44	4.88hi
ART08-2	115bc	02 August	Round	Green	Pink	71	5.49f
ART08-3	89e	11 July	Round	Yellow	Red	36	4.33j
ART08-4	129ab	14 July	Oblate	Green	Red	48	4.72i
ART08-5	119bc	20 July	Conic	Green	Green	55	6.79b
ART08-6	105cd	23 July	Round	Yellow	Pink	70	7.11a
ART08-7	99d	07 August	Oblate	Green	Red	29	6.30cd
ART08-8	121b	11 July	Round	Green	Purple	37	6.13de
ART08-9	132a	01 August	Oblate	Green	Red	66	5.60ef
ART08-10	95de	19 July	Oblate	Green	Red	80	6.51c
ART08-11	124ab	27 July	Conic	Green	Red	45	5.69ef
ART08-12	113bc	13 August	Round	Green	Pink	56	5.37fg
ART08-13	102cd	20 July	Oblate	Yellow	Red	50	4.80hi
ART08-14	107cd	25 July	Oblate	Green	Pink	64	5.10gh
ART08-15	120bc	28 July	Conic	Yellow	Pink	70	6.02de
ART08-16	117bc	22 July	Round	Green	Pink	47	7.02ab
ART08-17	91de	30 July	Oblate	Yellow	Red	35	5.90e
ART08-18	122b	27 July	Round	Green	Red	52	4.92h
ART08-19	93de	18 July	Oblate	Green	Red	88	5.00gh
ART08-20	113bc	04 August	Round	Green	Green	77	6.20d
ART08-21	127ab	02 August	Oblate	Green	Pink	59	5.20g
ART08-22	125ab	23 July	Conic	Green	Red	40	5.41fg
Summerred	104cd	30 July	Oblate	Green	Red	81	5.66ef

Same letters in same column indicate statistically significant differences ($p < 0.05$) among the genotypes.

product market (Sun et al., 2012). Common fruit shapes include round, conic, oblate, oblique, oblong, and ovate in apple and in general genetically controlled. Fruit shape may also differ by growing location depending on environmental conditions (Cao et al., 2015).

In summer apple samples from Artvin province, it was found that fruit over color were green, red, purple, yellow and pink and red color was dominant (12 genotypes). Fruit ground color shows low diversity (green and yellow) (Table 1). Over color coverage were found between 29-88% (Table 1). Ozrenk et al. (2011) reported that yellow and green ground skin color and yellow, green and red over color is common in local apple cultivars sampled from eastern Turkey. Kaya et al. (2015) studied a large number of apple genotypes and reported yellow and green ground color. They found great variability on over color which were red, pink, yellow and green. Apples show great diversity on external fruit surface color and ripening stage, skin (surface) of apple fruits is generally red, yellow, green, pink, or russeted, though many bi-or-tri-colored cultivars may be found. Fruit surface color is complex due to genetics and mutations, environmental factors, crop load, plant nutrition, plant stresses, and plant growth regulators

(Dobrzanski and Rybczynski, 2002). Red color in apples in general preferred by consumers and red color is strongly related to anthocyanin accumulation. Some cultivars lack the ability to synthesize large quantities of anthocyanin (red color agent). 'Golden Delicious' and 'Granny Smith' are examples of cultivars that develop little red color.

Fruit firmness is considered as one of the most important a quality parameter of apples which is closely related to respiration and evapotranspiration rates and thus with Ca content (Ghafir et al., 2009). We found fruit firmness of summer apple genotypes sampled from Artvin province were between 4.33-7.11 kg/cm² and cv. Summerred had 5.66 kg/cm² fruit firmness (Table 1). Ozrenk et al. (2011) reported fruit firmness between 3.9-6.2 kg/cm² in local apple cultivars, which supports our findings. Karlidag and Esitken (2006) determined the fruit firmness values of the local apple cultivars grown in upper Çoruh valley in the range of 3.70-5.25 kg/cm². Consumers usually reject apples with a firmness of less than 4.5 kg/cm² and, therefore, this is the minimum acceptable firmness level for many soft cultivars (Prange et al., 1993). Most apple quality characteristics, including fruit firmness, are genetically controlled and thus vary with cultivar. For example, Granny

Smith apples are firmer than most other cultivars, whereas McIntosh apples are among the softest (Malenfant, 1998). Skendrovic Babojelic et al. (2007) reported that among apple cultivars 'Pink Lady' was the hardest cultivar with average value of 7.3 kg/cm² fruit firmness, followed by 'Granny Smith' which had average value of 6.4 kg/cm² while 'Idared' had average fruit firmness of 4.5 kg/cm².

3.3. Sensory analysis

Table 2 shows results of sensory analysis (fruit taste, juiciness and aroma) by panelists. The results revealed big differences among genotypes on sensory characteristics. Most of the summer apple genotypes had sweet-sour (10 genotypes) taste. The cv. Summered had also Sweet-Sour taste, and followed by sweet and sour equally (6 genotypes each). For considering juiciness, the majority of genotypes had moderate juiciness (10 genotypes) as cv. Summered. Eight genotypes had low and four genotypes had high fruit juiciness. Considering aroma, eleven genotypes had high aroma, seven genotypes had moderate aroma and five genotypes had low aroma characteristics. The standard cultivar Summered had moderate aroma as majority summer apples (Table 2). Hajnajari et al. (2019) conducted a study in Iran on summer apples and they reported

Table 2. Sensory features of summer apple genotypes.

Genotypes	Sensory features		
	Taste	Juiciness	Aroma
ART08-1	Sour	Low	High
ART08-2	Sour	Moderate	Moderate
ART08-3	Sweet-Sour	Moderate	Moderate
ART08-4	Sweet	High	Low
ART08-5	Sweet-Sour	High	Low
ART08-6	Sweet-Sour	Moderate	Moderate
ART08-7	Sweet-Sour	Low	High
ART08-8	Sour	Low	Moderate
ART08-9	Sweet	Moderate	Moderate
ART08-10	Sweet	High	Moderate
ART08-11	Sweet	Moderate	High
ART08-12	Sour	Low	Low
ART08-13	Sweet-Sour	Low	Moderate
ART08-14	Sweet-Sour	Moderate	Moderate
ART08-15	Sweet	High	High
ART08-16	Sweet-Sour	Low	Moderate
ART08-17	Sweet-Sour	Moderate	Moderate
ART08-18	Sweet	Low	Low
ART08-19	Sour	Moderate	High
ART08-20	Sweet-Sour	Low	Moderate
ART08-21	Sweet-Sour	Moderate	Low
ART08-22	Sour	Moderate	High
Summered	Sweet-Sour	Moderate	Moderate

that based on the results of the sensory evaluation they found that the genotypes had diverse taste and aroma characteristics. Kalkisim et al. (2016) determined that local apple cultivars had equal sweet, sour and tart fruit taste. Some phytochemicals such as sugars, organic acids, and phenolic compounds contribute to the aroma of apples (Mikulic-Petkovsek et al., 2009). Zhu et al. (2018) reported great differences among eight apple cultivars in terms of sensory characteristics. It is generally recognized that the sensory characteristics of fruit varies qualitatively and quantitatively depending on the cultivar, maturity stage, climate and cultural conditions, and the production area for each cultivar and consumers are capable of distinguishing all sensory attributes (taste, juiciness and aroma) with a high degree of sensitivity (Mendoza et al., 2014). Various studies reported sensory characteristics followed by health considerations among primary factors for increase in fruit consumption (Verbeke, 2006; Enneking et al., 2007; Poole et al., 2007).

3.4. Biochemical analysis

There were statistically significant differences ($p < 0.05$) among analyzed summer apple genotypes in individual organic acids (Table 3). The major organic acids were malic acid (2.11-4.04 mg/100 mL) and followed by citric acid (0.24-0.85 mg/100 mL), succinic acid (0.22-0.53 mg/100 mL), oxalic acid (0.17-0.32 mg/100 mL) and tartaric acid (0.15-0.25 mg/100 mL), respectively (Table 3). Gundogdu et al. (2018) reported that malic, citric, succinic, oxalic and tartaric acid content between 2.06-4.62 mg/100 mL, 0.15-0.57 mg/100 mL, 0.18-0.51 mg/100 mL, 0.16-0.33 mg/100 mL and 0.04-0.17 mg/100 mL, respectively indicating similarities with our results. Wu et al. (2007) and Mikulic-Petkovsek et al. (2007) determined that the highest organic acid in apple fruits was malic acid and organic acid content quite variable among apple cultivars. Ma et al. (2018) found significant variation in organic acid components in mature fruits of 101 apple accessions. Organic acids have an effect on the sensory properties and nutritional value of fruits. The content of organic acids in fruit juices not only influences their flavor but also their stability, nutrition, acceptability and keeping quality. Besides their importance in flavor, organic acids are important in gelling product processing because they affect the gelling properties of pectin. The sugar/acid ratio is responsible for the taste and flavour of apples (Mikulic Petkovsek et al., 2007; Wu et al., 2007; Campeanu et al., 2009).

Table 4 shows SSC, titratable acidity, vitamin C, total phenolic content and antioxidant capacity of 22 summer apple genotypes and cv. Summered. The genotypes showed statistically significant differences ($p < 0.05$) among genotypes for total phenolic content and antioxidant capacity. There were no significant differences among summer apple genotypes for vitamin C content. The genotypes exhibited SSC content between 9.70-12.85% and cv. Summered had SSC content 12.10% (Table 4). In general early ripened genotypes had low SSC content when compared to late ripened genotypes (Table 4). SSC content widely used to make better comparison of

Table 3. Organic acid content of summer apples (mg/100 mL).

Genotypes	Malic	Citric	Succinic	Oxalic	Tartaric
ART08-1	4.04a	0.85a	0.53 ^{NS}	0.30 ^{NS}	0.25 ^{NS}
ART08-2	3.77ab	0.73ab	0.41	0.27	0.20
ART08-3	2.95cd	0.36bc	0.33	0.22	0.15
ART08-4	2.28de	0.30bc	0.30	0.17	0.22
ART08-5	2.86cd	0.44bc	0.37	0.23	0.20
ART08-6	2.90cd	0.40bc	0.40	0.18	0.18
ART08-7	3.02cd	0.60b	0.30	0.26	0.22
ART08-8	3.91ab	0.49b	0.25	0.32	0.20
ART08-9	2.50de	0.65ab	0.28	0.22	0.15
ART08-10	2.11e	0.29bc	0.24	0.18	0.23
ART08-11	2.30de	0.40bc	0.27	0.30	0.17
ART08-12	3.60b	0.80ab	0.22	0.25	0.20
ART08-13	2.74d	0.70ab	0.30	0.30	0.15
ART08-14	2.44de	0.33bc	0.35	0.28	0.25
ART08-15	2.20de	0.24c	0.33	0.19	0.18
ART08-16	3.11cd	0.73ab	0.37	0.22	0.17
ART08-17	3.30bc	0.76ab	0.22	0.17	0.15
ART08-18	2.85cd	0.48bc	0.35	0.20	0.23
ART08-19	3.57de	0.77ab	0.38	0.22	0.17
ART08-20	3.20c	0.69ab	0.25	0.25	0.21
ART08-21	3.11cd	0.50b	0.40	0.27	0.24
ART08-22	3.80ab	0.55ab	0.35	0.18	0.22
Summerred	3.35bc	0.58ab	0.32	0.30	0.18

Same letters in same column indicate statistically significant differences ($p < 0.05$) among the genotypes.

apple cultivars and in Turkey, SSC content were found between 9.10-15.4%. Previous studies revealed variable SSC content among apple cultivars and genotypes. SSC content previously reported between 10.0-15.4% among local apple genotypes and standard cultivars grown in different aproclimatic region in Turkey (Balta and Uca, 1996; Polat and Caliskan, 2007; Karlidag and Esitken, 2006; Ozrenk et al., 2011). Sweet taste of fruits depends on the soluble solids content (SSC), which is an important index on fruit quality, so the determination of SSC contents in fresh fruits is an important food analysis way for evaluating fruit quality. Identification of apple fruit based on internal quality can also enhance the industry's competitiveness and profitability and assure consumer satisfaction.

Vitamin C (ascorbic acid) content of summer apple genotypes and cv. Summerred are given in Table 4. Vitamin C content of summer apple genotypes were low, which found between 5.0-8.6 mg/100 mL (Table 4). Lee et al. (2003) also indicated that apple fruits are vitamin C low fruits and vitamin C content of apple cultivars varied from 9.0 to 16.6 mg/100g. Markowski et al. (2009) reported vitamin C content between 5.1 mg/100 g (cv. Judor) and 7.3 mg/100 g (cv. Ariane) in French apple cultivars. Lončarić and Piližota (2014) reported vitamin C between 4.75-8.42 mg/100 g in apple cultivars. Nour et al. (2010)

reported low ascorbic acid contents (average 6.18 mg/100 g) with the exception of 'Red Boskoop' (18.7 mg/100 g) and 'Idared' (11.4 mg/100 g) among 15 apple cultivars in Romania. Ascorbic acid content of apples belongs to genetic background and also cultivation conditions and environmental also affects on it.

Total phenol content of summer apple genotypes and cv. Summerred is given in Table 4 and the result clearly indicates statistically significant differences among genotypes ($p < 0.05$). The genotypes ART08-1 had the highest total phenolic content (164 mg GAE per 100 g fresh weight base) and followed by ART08-2 (151 mg GAE) and ART08-7 (144 mg GAE per 100 g), respectively. The lowest total phenolic content was measured in ART08-4 genotype as 87 mg GAE per 100 g fresh weight base (Table 4). The standard cultivar Summerred had 135 mg GAE per 100 g total phenolic content (Table 4). In previous studies, total phenolic content were reported genotype dependent but harvest time, geographic location and storage conditions are also affect total phenolic content in apple (Guyot et al., 1998; Tsao et al., 2003; Lončarić and Piližota, 2014). In Italy, Vrhovsek et al. (2004) reported variable total phenolic content (66-212 mg GAE/100 g) and they found average 110 mg GAE/100 g total phenolic content with significant differences depending on the

Table 4. SSC, vitamin C, total phenolic content (TPC) and AC (antioxidant capacity) of summer apples.

Genotypes	SSC (%)	Vitamin C (mg/100 g)	TPC (mg GAE/100 g)	AC (μ mol of vitamin C equivalents/g)
ART08-1	9.80de	7.4 ^{NS}	164a	143a
ART08-2	12.80ab	6.6	151ab	135ab
ART08-3	9.70de	7.1	122cd	123b
ART08-4	10.60cd	5.0	87e	71de
ART08-5	9.90de	5.9	130bc	139ab
ART08-6	10.95c	6.0	115cd	120bc
ART08-7	11.70bc	6.4	144b	130ab
ART08-8	11.20bc	8.6	110cd	116bc
ART08-9	12.70ab	8.0	97de	77de
ART08-10	12.85ab	6.6	105d	83d
ART08-11	12.95a	8.1	112cd	93cd
ART08-12	12.75ab	7.0	140bc	135ab
ART08-13	9.95d	7.7	125c	128ab
ART08-14	11.95b	6.0	120cd	116bc
ART08-15	10.80cd	7.2	117cd	104c
ART08-16	10.95c	6.7	127bcd	128ab
ART08-17	11.80bc	7.0	120cd	132ab
ART08-18	12.70ab	8.3	106d	110bc
ART08-19	9.90de	6.0	136bc	125ab
ART08-20	12.05ab	7.9	132bc	122b
ART08-21	11.40bc	6.5	124c	130ab
ART08-22	10.05cd	5.5	130bc	120bc
Summerred	12.10bc	6.2	135bc	114bc

Same letters in same column indicate statistically significant differences ($p < 0.05$) among the genotypes.

apple cultivars used. Abaci and Sevindik (2014) also found great variability on total phenolic content on apples ranged from 46.9 to 112.2 mg GAE/100g. Our results were comparable with above all results. Polyphenols contribute antioxidant properties in apples and are related to human health because of their free radical scavenging activities (Kschonsek et al., 2018).

The antioxidant capacity of summer apple genotypes is shown in Table 4 and genotypes significantly differed each other in terms of antioxidant capacity. The highest antioxidant capacity was seen in ART08-01 genotype as 143 μ mol vitamin C equivalent/100 g fresh weight base while the lowest values was obtained from ART08-4 as 71 μ mol vitamin C equivalent/100 g fresh weight base. The standard cultivar Summerred had 114 μ mol vitamin C equivalent/100 g fresh weight base (Table 4). Wolfe et al. (2003) found that Rome Beauty apples had the highest antioxidant capacity (131 μ mol of vitamin C equivalents/g) when compared to that component of the other apples (72, 84, and 67 μ mol of vitamin C equivalents/g for Idared, Cortland, and Golden Delicious), respectively. Those values close to our results indicating importance of our summer apple genotypes for human health point of view. The main compounds with antioxidant properties

present in apples are polyphenols. The general opinion is that their concentration depends on the cultivar of a fruit, as well as on the fruit maturity degree, cultivation methods, soil and climatic conditions, and insolation (Duda-Chodak et al., 2010).

Principal coordinate analysis (PCoA) was applied to the data by using NTSYS 2.10e software, and the contribution rates of the first 3 principal coordinates were 45.8%, 26.3%, and 8.6%, respectively, accounting for 70.7% of the variance (Figure 1). The first principal coordinate (PCoA1), which explains 45.8% of the overall variance, is clearly identified with the fruit firmness, SSC, total phenolic content and antioxidant capacity (Data are not shown). Summer apple genotypes were partitioned into 3 distinct groups. PCoA Group 1, 2 and 3 included 6, 10 (including cv. Summerred) and 7 samples, respectively (Figure 1). The first group characterized by high fruit weight, fruit firmness and SSC content. PCoA revealed useful information on the characterization and comparison of summer apple germplasm in terms of morphological, sensory and biochemical data. Substantial dispersion of summer apple genotypes in the PCoA plot suggests a high level of diversity, which can make them attractive for future breeding programs and long-term conservation strategies.

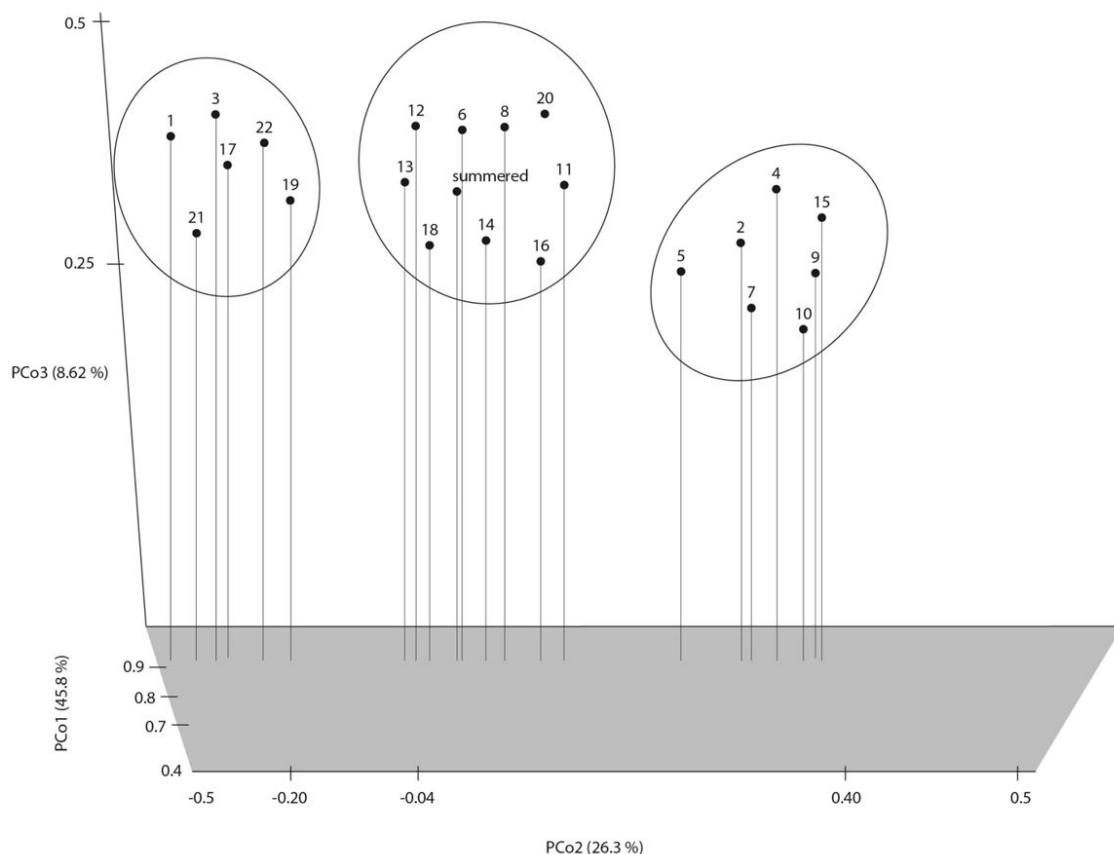


Figure 1. PCoA plot for the 22 analyzed summer apple genotypes and cv. Summerred (the genotype number codes on the plot refer to morphological and biochemical data).

4. Conclusion

The research accomplished confirmed a significant diversity in the morphological, sensory and biochemical properties among summer apple genotypes and suggested that phenological, morphological, sensory and biochemical properties are the most important factors for the characterisation of apple genotypes with respect to their nutritional value, potential use for different products and indicate their authenticity. The results could be base new studies on genetic improvement of summer apples. According to the results, most of the genotypes are indicated for potential use them in commercial production or breeding. The results was also assist in the in situ on farm conservation process of the evaluated apple genotypes.

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